DETERMINATION OF THE AVERAGE CYCLONIC FLOW ANGLE IN EXHAUST STACKS, DUCTS, AND VENTS

Purpose

This Meteorology and Air Quality Group (MAQ) procedure provides instruction for the measurement of average cyclonic flow angle (α or yaw angle) in LANL exhaust stacks, ducts, and vents using EPA Reference Method 1.

Scope

This procedure applies to the measurement of average cyclonic flow angle in all LANL exhaust stacks, ducts, and vents which are monitored for the MAQ Rad-NESHAP project.

In this Procedure

Hazard Control Plan

The hazard evaluation associated with this work is documented in Attachment 1: Initial risk = **low**. Residual risk = **low**. Work permits required: Radiation Work Permits, facility-specific permits.
First authorization review date is one year from group leader signature below; subsequent authorizations are on file in group office.

Signatures
(continued on next page)

Prepared by: Victor Martinez, MAQ	Date: **4/15/2004**
Approved by: Dave Fuehne, Rad-NESHAP Project Leader	Date: **4/19/04**
Work authorized by: Jean Dewart, MAQ Group Leader	Date: **4/19/04**

General information about this procedure

Signatures, *continued*

Approved by: Terry Morgan ? Terry Morgan, MAQ QA Officer	Date: **4/19/04**

Attachments

This procedure has the following attachments:

Number	Attachment Title	No. of pages
1	Hazard Control Plan	3
2	Cyclonic Flow Angle Measurement Form (Form 1-M)	1
3	Cyclonic Measurement Input Form (Form 1-R)	1
4	Cyclonic Measurement Input Form (Form 1-S)	1
5	Cyclonic Measurement Input Continuation Form (Form 1-C)	1

History of revision

This table lists the revision history and effective dates of this procedure.

Revision	Date	Description of Changes
0	4/24/98	New document.
1	1/6/00	Restructured text and attachments and revised many steps.
2	5/12/04	Revised to reflect work done by MAQ personnel instead of support contractors.

Who requires training to this procedure?

The following personnel require training before implementing this procedure:

- MAQ technicians and staff members who perform or support the exhaust stack, duct, or vent cyclonic flow measurements for the Rad-NESHAP project
- Task Order contractors (TOC) who perform or support the exhaust stack, duct, or vent cyclonic flow measurements for the Rad-NESHAP project.

General information, continued

Training method

The training methods for this procedure are:

- **on-the-job** training for task order contractors, technicians, and staff members *performing* cyclonic flow measurements, conducted by an individual with appropriate technical knowledge as determined and designated by the Rad-NESHAP Project Leader.
- "**self-study**" (reading) for any personnel *supporting* cyclonic flow measurements and for those previously trained to Revision 1 of this procedure.

Annual retraining is required and will be by "self-study" (reading). Training is documented in accordance with the procedure for training (MAQ-024).

Prerequisites

In addition to training to this procedure, the following training or surveillance programs are also required for all personnel prior to performing cyclonic flow measurements:

- MAQ-Field, "General Field Safety for All Employees" Radiological Worker Training
- Site-specific training as required for each facility
- Training as specified in each facility-specific IWD
- MAQ-127, "Determination of Stack Gas Velocity and Flow Rate in Exhaust Stacks, Ducts, and Vents"

Recommended training

The following training is recommended, but not required:

- Tritium Safety
- Plutonium Safety
- Beryllium Health Hazards
- Hazard Communication Introduction

General information, continued

Definitions specific to this procedure

EDM: Electronic Digital Manometer

FMU: Facility Management Unit

IWD: Integrated Work Document

LIR: Laboratory Implementation Requirement

NIST: National Institute of Standards and Technology

References

The following documents are referenced in this procedure:

National Codes and Standards

- 40 CFR 61 Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities"
- Method 1: EPA 40 CFR 60 Appendix A Test Method, "Sample And Velocity Traverses For Stationary Sources"
- Method 1A: EPA 40 CFR 60 Appendix A Test Method, "Sample And Velocity Traverses For Stationary Sources With Small Stacks Or Ducts"
- Method 2: EPA 40 CFR 60 Appendix A Test Method, "Determination Of Stack Gas Velocity And Volumetric Flow Rate (Type S Pitot Tube)"
- Method 2C: EPA 40 CFR 60 Appendix A Test Method, "Determination Of Stack Gas Velocity And Volumetric Flow Rate In Small Stacks Or Ducts (Standard Pitot Tube)"

Los Alamos National Laboratory Requirements

- LIR 230-03-01, "Facility Management Work Control"
- LIR 402-10-01, "Hazard Analysis and Control for Facility Work"
- LIR 402-704-01, "Contamination Control"

MAQ Procedures

- MAQ-Field, "General Field Safety for All Employees" MAQ-024, "Personnel Training"
- MAQ-026, "Deficiency Reporting and Correcting"
- MAQ-127, "Determination Of Stack Gas Velocity and Flow Rate in Exhaust Stacks, Ducts, and Vents"
- MAQ-141, "Calibration and Evaluation of Pitot Tubes for Stack Flow Measurements"

Manufacturer's Literature

- Refer to the manufacturer's literature for each instrument

Work control

General

MAQ technicians and/or staff members must coordinate all work associated with the Rad-NESHAP program with the appropriate facility management unit in accordance with LIR 230-03-01, "Facility Management Work Control."

Facility check-in and check-out

Special check-in and check-out procedures must be followed when working in all LANL facilities. Personnel assigned to perform the cyclonic flow measurements shall ensure that all check-in and check-out procedures are followed as outlined in the facility's site-specific training.

Measurement frequency

Cyclonic flow measurements are performed at a site to determine if it meets EPA Reference Method 1's criteria for Method 2 flow measurements and/or sample collection. These measurements are generally performed only one time at a site.

Safety and Hazard Analysis

ES&H hazard screening

All hazards will be identified and mitigated according to the Integrated Work Management process.

Potential hazards to consider

The following types of hazards may be present during air flow measurements and must be identified in the appropriate integrated work document (IWD):

- radiation
- chemical emissions
- rotating machinery
- heights (e.g., roofs, scaffolding, bucket truck, etc.)
- weather (e.g., lightning, snow, ice, etc.)
- noise
- heat exposure
- falling objects

Radiological hazards

Before scheduling access to roof tops or opening stack measurement ports, contact facility operational personnel, area work supervisors, and local RCTs to determine if planned laboratory processes could be producing unusual radiological hazards during the stack measurements.

Potentially contaminated equipment

Equipment used to measure airflow in potentially radioactive stacks must be cleared by the site radiological control technician in accordance with facility requirements and LIR 402-704-01, "Contamination Control." If radioactive contamination is detected, trained and qualified personnel must decontaminate the unit before it may be removed from the site.

Personal protection equipment

Safety shoes and safety glasses must be worn while performing all cyclonic flow measurements. The following additional personal protective equipment may be required and will be indicated in the facility IWD document:

- Hard hat
- Hearing protection
- Anti-contamination clothing including rubber gloves and booties

Permits

The **RRES-MAQ engineer** ensures all permits (e.g., radiation work permits, IWD, etc.) are issued before work begins.

Equipment specifications

Acceptable equipment

Specifications for equipment to be used to perform this procedure are given below. Other equipment meeting these specifications may be acceptable. **MAQ must obtain approval from EPA for substitute equipment not specified below.**

Type-S pitot tube

The Type-S pitot tube must be constructed of metal tubing (e.g., stainless steel) meeting the dimensional tolerances in EPA Reference Method 2 (MAQ-141). An identification number must be assigned to the pitot tube and be permanently marked or engraved on the body of the tube.

Differential pressure gauge

An oil-gauge manometer or equivalent device (EDM) must be used. If a device other than an oil-gauge manometer is used (such as an EDM), its calibration must be checked after each test series.

Special tools

The following special tools are needed to perform this procedure:

- pitot tube level.
- pitot tube square
- Steel mounting bracket
- protractor/angle finder

Equipment calibration

Equipment calibration records

Documented proof of calibration must be available for all measurement tools and instruments. The **individual responsible for calibration** files official calibration certificates in the MAQ records center and ensures each piece of equipment is marked with a calibration sticker (see OST308-00-00, "Laboratory Calibration Program" [http://www.esa-mt.lanl.gov/s&cl/calprog.html]).

Type-S pitot tube

The Type-S pitot tube must be calibrated according to the requirements of EPA Reference Method 2 (see MAQ-141, Attachments 2, 3, and 4).

Electronic Digital Manometer

An Electronic Digital Manometer (EDM) used (instead of an oil-gage manometer) to measure the cyclonic flow angle in the stack must be calibrated annually by ESA-AET or the manufacturer. Calibration must be traceable to NIST standards.

Prior to each use, it is highly recommended that a calibration check be performed on the EDM against an oil-gage manometer in the shop wind tunnel. Compare the VP readings of the EDM with those of an oil-gage manometer at a minimum of three points (high-medium-low). If, at each point, the values of VP, as read by the EDM and oil-gage manometer, agree to within 5 percent, consider the EDM to be in proper calibration and can be used for field measurements.

Measuring cyclonic flow

Background

In most stationary sources, the direction of the stack gas flow is essentially parallel to the stack walls. However, cyclonic flow may exist (1) after such devices as cyclones and inertial demisters following venturi scrubbers, or (2) in stacks having tangential inlets or other duct configurations that tend to induce swirling.

This procedure may only be used at measurement sites that meet the criteria of EPA Reference Method 1 or 1A (the site is at least 2 duct diameters downstream and ½ duct diameter upstream from a flow disturbance). Locations for performing measurements are identified by MAQ.

Exhaust stack measurement location (i.e., profile location)

MAQ will specify the location on the exhaust stack to perform cyclonic flow angle measurements. In addition, MAQ will specify the number of traverses, the number of measurement points, and their spacing along each traverse.

The measurement location, the number of traverses, and the number of measurement points along each traverse defines the profile. MAQ will identify each profile with a unique number.

Field measurement forms

Record all measurement field data on the Cyclonic Flow Angle Measurement Form (Attachment 2, Form 1-M) and the appropriate Cyclonic Measurement Input Form (Attachments 3 or 4), depending on whether the stack is round (Form 1-R) or rectangular (Form 1-S). A continuation form may also be used (Form 1-C).

Record all entries in ink. Correct any errors by striking through the erroneous entry with a single line and annotating the correct information in an empty space directly adjacent to the error. Initial the correction.

Field conditions

Only perform cyclonic flow angle measurements when an exhaust stack, duct, or vent is exhausting ambient air from a laboratory or facility.

Measuring cyclonic flow, continued

Steps to perform measurements

To measure cyclonic flow in a stack, duct, or vent, perform the following steps:

Step	Action
Determining the location for performing measurements	
1	Obtain the location on the stack or duct from the MAQ Engineer before performing the measurement. The location is identified by the profile measurement number.
Preparing equipment	
2	Select the correct Type-S pitot tube for the stack(s) to be analyzed. The tip of the pitot tube to be used must be free of any damage (see MAQ-127, Attachment 1). The selected pitot tube should be long enough to reach all traverse points through the cross-section of the stack(s) with the steel bracket attached. • Calculate the distances from the centerline of the pitot tube nozzle to each traverse point and mark the pitot tube with a felt-tipped pen so that the pitot can be correctly positioned from the hole in the stack wall to each traverse point. Have a second qualified stack measurement individual independently verify the markings. • Record the serial number of the type-S pitot tube(s) to be used in section 1 of the Cyclonic Flow Angle Measurement Form (Form 1-M). • Attach the steel bracket for the magnetic angle finder to the end of the s-type pitot tube. Verify the steel bracket is parallel to the sensing tips of the s-type pitot tube.
3	Verify that the EDM and type-S pitot tube calibration certifications have not expired. Record the following in section 1 of the Cyclonic Flow Angle Measurement Form (Form 1-M): • type of manometer (e.g., EDM) • serial number • calibration expiration date
Preparing measurement input forms	
4	Record the TA, building, exhaust stack (ES) ID Number and exhaust fan(s) numbers on the top of the Cyclonic Flow Angle Measurement Form (Attachment 1, "Form 1-M"). Also record the profile number and the fan configuration number. The ES ID Number is the eight digit number, TA-BLDG-ES, with leading zeros.
5	Record the date of the measurements on the top of the Cyclonic Flow Angle Measurement Form.

Steps continued on next page.

Measuring cyclonic flow, continued

Step	Action
Verifying exhaust system is exhausting ambient air and inspecting system	
6	Check with Facility Management before starting flow measurements to verify that the stack is not exhausting radioactive or other hazardous process exhaust. Only perform cyclonic flow angle measurements when an exhaust stack, duct, or vent is exhausting ambient air from a laboratory or facility.
7	Before measuring the cyclonic flow angles, inspect the exhaust system, i.e., fan(s), dampers, etc. Record, in section 2 of the Cyclonic Flow Angle Measurement Form, any unusual conditions or variations observed in the configuration of the exhaust system during the inspection. Report these findings to the Facility Management Unit before leaving the work area. **If conditions present may present a hazard, DO NOT perform the flow measurements. Report the conditions to the FMU and reschedule the flow measurement after the hazard has been mitigated.**
Setting up and adjusting equipment	
8	Connect the manometer to the Type-S pitot tube using capillary tubing in the manner described in the manufacturer's instructions. Record a check mark in the appropriate box in section 3 of the Cyclonic Flow Angle Measurement Form (Form 1-M).
9	**Optional** but recommended: Perform a pre-measurement leak check on the capillary tubing installed between the EDM and the s-type pitot tube. The capillary tubing must be air tight, holding a pressure of at least 3 inches of H_2O for 15 seconds. **Do Not Pressurize The Tube By Mouth!** • Seal the total pressure side of the pitot tube using a latex glove or rubber plug. Blow or pump ambient air into the total pressure side of the system until at least 3 inches of pressure registers on the EDM. Close off the tube using the installed valve. The pressure reading should remain stable for at least 15 seconds. • Next, seal the static pressure side of the pitot tube using a latex glove or rubber plug. Pull a 3 inch vacuum on the static pressure side. Close off the tube using the installed valve. The negative pressure reading should remain stable for at least 15 seconds after the tube is closed. Record a check in the appropriate box in section 3 of the Cyclonic Flow Angle Measurement Form (Form 1-M). If the system does not pass the leak test, correct the problem, perform a second leak check test and document the problem and solution.

Steps continued on next page.

Measuring cyclonic flow, continued

Step	Action
10	Adjust the EDM sensitivity to the gauge setting recommended by the manufacturer for the pressure anticipated. Record a check mark in the appropriate box in section 3 of the Cyclonic Flow Angle Measurement Form.
11	Zero the manometer. Because the manometer zero may drift due to vibrations and temperature changes, make periodic checks during the traverse. Record a check mark in the appropriate box in section 3 of the form.
Performing traverse readings	
12	Don all required PPE as specified in the RWP and any other applicable work permits.
13	Record the time of the first reading in section 4 of the Cyclonic Flow Angle Measurement Form.
14	Remove the plug covering the measurement port as each port is used and insert the Type-S pitot tube to the first measurement point.
15	If possible, seal the opening between the stack wall and the pitot tube.
16	Verify with a level and square that the S-type pitot tube is parallel to the cross-sectional plane of the stack and that the plane of the face opening of the pitot tube is perpendicular to the stack cross-sectional plane. The level and square tool must be attached parallel to the center line axis of the stack. Attach the magnetic angle finder to the steel bracket. Verify angle finder is at 0° in this configuration. **IMPORTANT: The pitot tube MUST be level and the face openings MUST be parallel to the center line of the stack.** The pitot tube is in the 0° reference position.
17	Record the differential pressure (Δp) at the 0° reference position on the appropriate Cyclonic Measurement Input Form (see Attachments 2 - 4). If the Δp reading is not zero, then rotate the pitot tube (up to ±90° yaw angle) until a zero reading is obtained on the EDM. Read the yaw angle from the angle finder and determine the direction of rotation (clockwise or counter-clockwise) to obtain the zero reading. Record the yaw angle to the nearest degree and the direction of rotation.
18	Repeat Steps 15, 16, and 17 at all traverse points specified by EPA Reference Method 1 or 1A (provided by MAQ). Reinsert the plug into the measurement port after each traverse has been completed. Record a check in the box in section 7 of the Cyclonic Flow Angle Measurement Form
19	Record the time of the last reading in section 4 of the Cyclonic Flow Angle Measurement Form.

Steps continued on next page.

Measuring cyclonic flow, continued

Step	Action
20	Perform a post-measurement leak check on the capillary tubing installed between the EDM and the s-type pitot tube. The capillary tubing must be air tight, holding a pressure of at least 3 inches of H_2O for 15 seconds. **Do Not Pressurize The Tube By Mouth!** • Seal the total pressure side of the pitot tube using a latex glove or rubber plug. Blow or pump ambient air into the total pressure side of the system until at least 3 inches of pressure registers on the EDM. Close off the tube using the installed valve. The pressure reading should remain stable for at least 15 seconds. • Next, seal the static pressure side of the pitot tube using a latex glove or rubber plug. Pull a 3 inch vacuum on the static pressure side. Close off the tube using the installed valve. The negative pressure reading should remain stable for at least 15 seconds after the tube is closed. Record a check in the appropriate box in section 6 of the Cyclonic Flow Angle Measurement Form (Form 1-M). If the system does not pass the leak test, void the measurement, correct and document the problem, and repeat the flow measurements starting with step10.
21	Record any condition(s) that may affect the accuracy or the validity of the measurement data in section 6 of the Cyclonic Flow Angle Measurement Form.
22	Request an RCT to check all equipment for potential contamination. Follow all facility rules and RCT instructions for disposing of potentially contaminated PPE and supplies.
23	Inspect the work site to be sure all equipment and tools have been collected.
24	Depart facility, complying with all facility requirements as needed. Notify facility personnel that all measurements have been completed.

Perform post-measurement verification

If a manometer other than an oil-gage manometer was used (e.g., EDM), then a post-measurement verification must be performed. Verify the accuracy of the reading on the EDM against another calibrated manometer (or an oil-gage manometer). The readings should not deviate more than ±5% from the instrument that was used in the field. Follow the steps in the chapters *Post-measurement verification* and *Using the Wind Tunnel* in procedure MAQ-127.

Completing and submitting forms

Complete, sign, and forward the forms to the MAQ QA reviewer for the calculation and/or verification of the cyclonic flow angle measurements.

Performing calculations

Verify data collection

The **MAQ QA reviewer** verifies that the procedural steps were followed, data are properly recorded and within range expected for that parameter, and (if data were transcribed from a field work sheet to a final copy of the form) there are no transcription errors. Document the performance of these steps by signing the forms in the space "QA check by:"

Performing cyclonic flow angle calculations

The **MAQ QA reviewer** performs calculations in accordance with the instructions below. Retain at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculation. Record the results on the forms in the appropriate spaces. Sign the bottom of the forms in the space "Calculations by:" to indicate that all data have been reviewed and verified as described in the block above.

Calculate average rotation angle

Average rotation angle: $$\alpha = \frac{\sum_{i=1}^{i=n} \alpha_i}{n}$$

where:

i = the traverse number
n = the total number of measurement points

Acceptable rotation angle

α must be less than or equal to 20° for the site to be acceptable for either flow measurements or sample collection.

Forward forms for MAQ Verification

Forward all forms to the MAQ Engineer with the original cyclonic flow measurement forms [Attachment 2 (Form 1-M) and Attachments 3, 4, or 5 if used] **within one week** of performing flow measurements.

Reviewing and verifying calculations

Review and verify calculations	The **MAQ engineer** receives the forms from the MAQ QA reviewer and performs a detailed review and verification of all data and calculations. Sign the forms in the space "MAQ approval by:" to indicate approval of data and calculation results.
Submit records	The **MAQ engineer** files the forms in the MAQ Records Center.

Records resulting from this procedure

Records

The following records generated as a result of this procedure are to be submitted as records **within two weeks of completion** to the group records coordinator:

- Attachment 2 (Form 1-M)
- At least one of the following forms, as appropriate:
  - Attachment 3 [Cyclonic Measurement Input Form (Form 1-R)]
  - Attachment 4 [Cyclonic Measurement Input Form (Form 1-S)]
- Attachment 5 [Cyclonic Measurement Input Continuation Form (Form 1-C)], if used

HAZARD CONTROL PLAN

1. The work to be performed is described in this procedure.
"Determination Of The Average Cyclonic Flow Angle In Exhaust Stacks, Ducts, And Vents"

2. Describe potential hazards associated with the work (use continuation page if needed).

a) Radiological hazards - Potiental contamination from contact with port plugs, pitot tubes, and other equipment that is inserted into the exhaust stack of duct. Radiological hazards may also be present from work in radiologically controlled areas.
b) hand tools - nicks, cuts, bruises from using tools.
c) Work at elevation (ladders, scaffolding, bucket truck) - slips & falls from equipment
d) General work area hazards - uneven flooring, noise, low headroom, cramped conditions
e) Facility-specific hazards - Emergency response
f) Over head work – Potential of falling objects.
g) Stack air - Workers may be exposed to pollutants in stack (rad, non-rad, chemicals) while measurement ports are open.
h) Rotating Machinery – Work will be performed in mechanical rooms and near exhaust fans.
i) Weather – Heat exposure, cold weather, wind, lighting, rain
j) Noise from wind tunnel and mechanical equipment --When running, the wind tunnel produces some noise, but levels are well below levels that require hearing protection. Other facility areas may have hearing protection requirements.

3. For each hazard, list the likelihood and severity, and the resulting initial risk level (before any work controls are applied, as determined according to LIR300-00-01, section 7.2)

a) Radiological hazards - (all) frequent / negligible = Low
b) hand tools - occasional / moderate = Low
c) work at elevation (ladders, scaffolding, bucket truck) - occasional / moderate = Low
d) General work area hazards: occasional / moderate = Low
e) Facility-specific hazards: occasional / moderate = Low
f) Overhead Work - occasional / moderate = Low
g) Stack air exposure: occasional / moderate = Low
h) Rotating Machinery – occasional / moderate = Low
i) Weather – occasional / moderate = Low

Overall initial risk: ☐ Minimal ☒ Low ☐ Medium ☐ High

4. Applicable Laboratory, facility, or activity operational requirements directly related to the work:

☐ None ☒ List: Work Permits required? ☐ No ☒ List:

LIR-402-706-01 "Personnel Dosimetry"
Radiological work permit may be required for work that is performed inside the exhaust stack. Consult with facility HSR-1 team before performing stack flow measurements to ensure facility-specific radiological requirements have not changed. Other facility-specific requirements may apply for some locations. Contact FMU operations.

HAZARD CONTROL PLAN, continued

5. Describe how the hazards listed above will be mitigated (e.g., safety equipment, administrative controls, etc.):

a) Rad hazards: Rad-Worker II training, obey all postings, minimize time in any radiological area. Wear rubber gloves whenever in contact with equipment that has been inside the exhaust stack or duct. Before leaving work area, RCT must survey all equipment that was inside the stack.

b) Hand tools: work in a calm, unhurried manner. Wear leather gloves as needed.

c) Ladders/Scaffolding/Bucket Truck: Take required training (see item 6). Wear closed-toe footwear with non-slip soles when climbing ladders or scaffolding. When climbing, keep hands free of any items. Transport work items to working platform by means of a back pack or lift & lower with container and rope, as appropriate. Learn the weight limit of the scaffold & ensure it is not exceeded. When working from bucket, ensure you wear the appropriate fall protection harness and do not over-reach and keep arms inside the bucket while it is being moved.

This procedure requires two people minimum for all work in facilities.

See continuation page.

6. Knowledge, skills, abilities, and training necessary to safely perform this work (check one or both):

☒ Group-level orientation (per MAQ-032) and training to this procedure.

☒ Other → See training prerequisites on procedure page 3. Any additional describe here:

Rad Worker training. Facility-specific training.
Scaffolding Training or Ladder Safety for airflow measurements that requires the work to be performed from elevated surfaces.

7. Any wastes and/or residual materials? (check one) ☒ None ☐ List:

PPE and HSR-1 materials (used to survey equipment for release) to be disposed of by facility personnel.

8. Considering the administrative and engineering controls to be used, the *residual* risk level (as determined according to LIR300-00-01, section 7.3.3) is (check one):

☐ Minimal ☒ Low ☐ Medium (requires approval by Division Director)

9. Emergency actions to take in event of control failures or abnormal operation (check one):

☐ None ☒ List:

For all injuries, provide first aid and see that injured person is taken to Occupation Medicine (for minor injuries and follow-up) or the hospital (if immediate medical attention is required). Notify the Operations manager of the injury. For any exposed, energized electrical wires, contact KSL or the appropriate authority to turn off the power. Follow all site specific emergency plans for any radiation or other emergencies.

Signature of preparer of this HCP: This HCP was prepared by a knowledgeable individual and reviewed in accordance with requirements in LIR 300-00-01 and LIR 300-00-02.

Preparer(s) signature(s)	Name(s) (print) /Position	Date

Signature by group leader on procedure title page signifies authorization to perform work for personnel properly trained to this procedure. This authorization will be renewed annually and documented in MAQ records. Controlled copies are considered authorized. Work will be performed to controlled copies only. This plan and procedure will be revised according to MAQ-022 and distributed according to MAQ-030.

HAZARD CONTROL PLAN, continued

Hazard Control Plan continuation page. Give item number being continued.

#3) Initial Risk Level:

j) noise from wind tunnel -- occasional / moderate = low

5. How hazards are Mitigated:

d) Work area hazards: work in a calm, unhurried manner.

e) Facility-specific hazards: Have appropriate training, or be under escort by a qualified worker.

f) Overhead work: Requirements when work is being conducted at elevation (e.g., on scaffolding)

- All workers near scaffolding will wear hard hats and safety shoes when work is going on above.
- Keep all non-participants outside of the "cone of danger" by controlling access to work area.
- Secure equipment on the scaffolding or store in a container that is secured to the scaffolding.
- Workers on the ground shall remain outside the cone of danger during activities on the scaffolding or the bucket truck, unless actively assisting with hoisting or lowering.

g) Stack air: consult with HSR-1 (rad) and facility operations (non-rad & chemicals) to determine if special controls or PPE should be used during air flow measurement work

h) Rotating Machinery: Keep safe distance from moving parts. Ensure all rotating equipment have adequate guarding. If any guards are missing, stop work and report condition to facility manager.

i) Weather: Wear appropriate clothing for the climate. Wear hats, sunscreen and long sleeve shirts to avoid sunburn. Apply the 30/30 rule for situations where there is evidence of an approaching lightning storm. Do not perform measurements under high wind conditions (25 mph, sustained)

j) Noise: Use hearing protection (recommended) if working for more than a few minutes around operating wind tunnel or other high noise sources.

Meteorology and Air Quality Group

Cyclonic Flow Angle Measurement Form (Form 1-M)

Page 1 of 1 This form is from MAQ-128

TA/Building/ES _____-_____-_____ FE(s) _____ Date _____/_____/_____

Profile Measurement Number _____ Fan Exhaust Configuration _____

1. Equipment used and calibration

Manometer _____ Serial Number _____ Calibration Expiration ____/____/____

Pitot Tube Type-S Serial Number _____

☐ Traverse spacing pre-marked on pitot tube / pitot tube inspected

2. Location inspection

Location Comments: _____

3. Equipment setup

☐ Connect manometer to tubing ☐ Pre-test leak test performed

☐ Adjust manometer sensitivity ☐ Level and zero the manometer

4. Perform traverse readings (record velocity pressure and angle)

Run Start Time: _____ Run Complete Time: _____

5. Post measurement leak test (3" wg)

☐ successful ☐ measurement voided

6. Condition which might affect measurements

_____

7. Holes covered

☐ Complete

8. Manometer Verification

☐ Manometer verification passed (within 5%) ☐ Manometer verification not required.

Test Number		Velocity Pressure (inches wg)		
		Manometer	Reference	% Difference
1				
2				
3				

Measurements by:

_____ _____ _____ _____/_____/_____

Signature Print name Z-Number Date

MAQ QA check by:

_____ _____ _____ _____/_____/_____

Signature Print name Z-Number Date

MAQ approval by:

_____ _____ _____ _____/_____/_____

Signature Print name Z-Number Date

Meteorology and Air Quality Group

Cyclonic Measurement Input Form (Form 1-R)

(2 x 12 Round Stack or Duct)

Page 1 of 1 This form is from MAQ-128

TA/Building/ES _____-_____-_____ Measurement Date _____/_____/_____

Measurement Traverse A				Measurement Traverse B			
Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0	Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0
A1				B1			
A2				B2			
A3				B3			
A4				B4			
A5				B5			
A6				B6			
A7				B7			
A8				B8			
A9				B9			
A10				B10			
A11				B11			
A12				B12			
Sum α for A1 - A12				Sum α for B1 - B12			
Average α is							

Cyclonic flow measurements were made in accordance with MAQ-128.

Measurements by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

Calculations by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

QA review by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

MAQ QA review by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

MAQ approval by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

Meteorology and Air Quality Group

Cyclonic Measurement Input Form (Form 1-S)
(6 x 5 Rectangular Stack or Duct)

Page 1 of 1 This form is from MAQ-128

TA/Building/ES _____-_____-_____ Measurement Date _____/_____/_____

Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0	Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0
A1				B1			
A				B2			
A3				B3			
A4				B4			
A5				B5			
C1				D1			
C2				D2			
C3				D3			
C4				D4			
C5				D5			
E1				F1			
E2				F2			
E3				F3			
E4				F4			
E5				F5			
Sum of α angles A/C/E				Sum of α angles B/D/F			
Average α angle is							

Flow measurements were made in accordance with MAQ-128.
Measurements by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

Calculations by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

MAQ review and approval by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

Meteorology and Air Quality Group

Cyclonic Measurement Input Continuation Form (Form 1-C)

Page 1 of 1 This form is from MAQ-128

TA/Building/ES _____-_____-_____ Measurement Date _____/_____/_____

Measurement Traverse ____				Measurement Traverse ____			
Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0	Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0
Sum of α angles				Sum of α angles			
Average α angle is							

Flow measurements were made in accordance with MAQ-128.
Measurements by:

_____	_____	_____	_____/_____/_____
Signature	Print name	Z-Number	Date

Calculations by:

_____	_____	_____	_____/_____/_____
Signature	Print name	Z-Number	Date

MAQ review and approval by:

_____	_____	_____	_____/_____/_____
Signature	Print name	Z-Number	Date